

PREDICTIVE AND PRESCRIPTIVE ANALYSES: THEORETICAL CONSIDERATIONS***Vera G. KOGDENKO**National Research Nuclear University MEPhI, Moscow, Russian Federation
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analytics**Abstract****Subject** The article discusses theoretical considerations of predictive and prescriptive analyses.**Objectives** The research summarizes algorithms and aspects of predictive, prescriptive analysis and identifies points of corporate growth triggered by the use of digital analytics.**Methods** The research employs general principles and methods of research, such as analysis and synthesis, grouping and comparison, abstraction, generalization.**Results** The article characterizes predictive and prescriptive analyses, modeling algorithms and identifies six focal points for analysis. I focus on key algorithms for modern analysis, i.e. setting trends and regression models, clusterization and classification of data, detection of data deviations and association analysis. The article reviews the algorithm used to build models, which involves training and test datasets. As part of each analysis, I find key aspects and points of corporate performance growth.**Conclusions and Relevance** The article provides solutions for better business performance resulting from the use of digital analytics, i.e. adapting a product and marketing to customers' needs, reduction in the cost of business processes, articulation of the effective HR policy, making preventative decisions on fraudulent transactions, optimization of business model. The findings may be useful to analysts.

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As long as the economy gets more digitized, data become as valuable as other tangible assets, technology and brands. Therefore, business analytics evolves, relying on information technologies and summarizing theoretical aspects of predictive and prescriptive analysis. The aspects imply that data are converted into forecasts and any manipulations with the item in question should be justified in order to attain desired results through big data analysis and detection of correlations. Gartner's¹ analysts

emphasize the importance of analysis for today's businesses. In their opinion, using digital analytics, companies will be able to outgrow their competitors by 20%, thus monetizing bigger data. The analysis turns from observation to corporate governance and value creation². Based on the Artificial Intelligence unit (AI unit), digital analytics enhanced public administration since the use of resources is analyzed and controlled [1].

Predictive and prescriptive analyses have some key characteristics.

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¹ Gartner is the leading research and advisory company specializing in IT markets.

² Sirota Yu. *Intelligent transformatsya banka* [Intelligent transformation of the bank]. URL: <http://www.tadviser.ru/images/4/47/%D0%A1%D0%B8%D1%80%D0%BE%D1%82%D0%B0.pdf> (In Russ.)

1. They are based on a set of data (petabyte, exabyte, Zettabyte are measures of volume), which relate to the external and internal environment of a business and have three key traits, i.e. big volume, high growth pace and diversity.
2. They employ the induction mechanism. That is, common patterns are identified through the analysis of standalone cases.
3. They aim to verify hypotheses, find correlations, detect influencing factors and groups (clusters).
4. They are supposed to build models, which are developed and adapted through AI.
5. They provide for a walk-through integration of analytical algorithms within the single information space of a company.
6. They are oriented at activities, i.e. making managerial decisions on business changes.

Predictive and prescriptive analyses generate models and solutions. Hence, this task requires two groups of analysts, with the first one developing models and the second one raising issues and substantiating decisions [2]. Analysts of models handle data, offer forecasting tools and modeling methods, work out algorithms and make models, etc.³. Analysts of solutions focus on the cause-and-effect relationships, formulate hypotheses as abstract as needed, plan and evaluate experiments, give recommendations, set up metrics and panels of indices, analyze opportunities and priorities of the analysis, etc.⁴. It is the branch of analytics that evolved from the traditional economic analysis of smaller data, implying that routine analytical procedures are

³ Garten Y. The Kinds of Data Scientist.

URL: <https://hbr.org/2018/11/the-kinds-of-data-scientist>

⁴ Kachalov D.L., Mishustin A.V., Farkhadov M.P. [Modern Big Data processing methods in major systems]. *Matematicheskie modeli sovremennykh ekonomicheskikh protsessov, metody analiza i sinteza ekonomicheskikh mekhanizmov. Aktual'nye problemy i perspektivy menedzhmenta organizatsii v Rossii: materialy nauchnoi konferentsii* [Proc. Sci. Conf. Mathematical Models of Modern Economic Processes, Methods for Analysis and Synthesis of Economic Mechanisms. Current Challenges and Future of Corporate Government in Russia]. Samara, Samara Research Center for Russian Academy of Sciences Publ., 2017, pp. 65–70. URL: <https://www.ipu.ru/node/44754> (In Russ.)

automated, while creative analytics will be growing.

Nowadays analytics construes human behavior through typical patterns, which can be predicted and forecasted. There are numerous relationships, direct and indirect, which help find some indicators (predictors) of future events. Nevertheless, absolutely firm forecast is impossible. However, some approximate conclusions will suffice for the forecast to be of practical value [3]. Predictive analytics has another important aspect. It converts risks into opportunities, since it allows to envisage adequate risk management algorithms in case risks are detected.

Predictive and prescriptive analyses are confined to intellectual analysis of data (data mining, text mining, web mining, social mining). That is, they are intended to trace some models and trends in the dataset, including

- setting up trends: forecast of some quantitative indicators, whether financial and non-financial. For example, forecasting the number of buyers;
- regression analysis and search for a function for variables. For example, setting up a sales equation;
- classifications (supervised learning), i.e. data distribution among the predetermined classes. For example, assigning an employee to a certain class and revealing his/her propensity to quit;
- clusterization (unsupervised learning), i.e. data distribution among non-predetermined classes. For example, search for groups of clients with similar characteristics, market segmentation;
- association analysis, i.e. discovering some patterns in related events, relations among variables. For example, sales of different goods;
- discovering anomalies (supervised learning). For example, spotting untypical transactions to detect fraud.

Modeling is the central part of modern analytical practices. A model is the centerpiece of the

modeling process. It is an abstract presentation which deliberately simplifies a phenomenon, being a stable inner relationship of variables [4]. The model can look like a decision tree or multifactor equation. *Fig. 1* shows the algorithm to build models as part of predictive and prescriptive analyses.

Big data are used to build models. They require clear regulations and rules for data mining, processing, storage, access, administration, that is, answers to arising questions [3]:

1. What data should be stored? How long?
2. Which employees and third parties shall have access to data?;
3. What should be done with data? For example, which data are aggregated and processed?

At the initial phase of data processing, principal trends are revealed, with the noise being cutting off [5]. Data are subsequently grouped into two populations, i.e. training set meant for modeling and including 70–80 percent of total data, and testing set including 20–30 percent of data and meant to probate models.

Lift ratio measures the efficiency of models based on data sets. Lift ratio shows the extent to which the model is more efficient than a random decision. The efficiency metric of the targeting model (a choice of target customers) indicates the extent to which a model produces a more precise sample than random sampling. The model is evaluated with the test set of data, if lift ratio of the test data as the model gets more complicated. This signifies that the model was overtrained, thus being less efficient if further improved. Test dataset allows to find the best model, avoiding its insufficient or excessive training [3]. The reliability of analysis results is checked *inter alia* through back-setting, that is, verification of forecasts with the previous data.

Analyzing the efficiency of the model, the correlation of its accuracy and complexity is investigated (the size of the decision tree or the number of factors involved in the equation). Sophistication attempts may face the limitation based on the Occam's razor principle, holding that *entities should not be multiplied without*

necessity. This rule applies to a standalone mode. However, using a set of simple models together, i.e. transition to an assembly of models, will raise the quality of forecasts. Hence, modeling may imply concurrent creation of several models and their subsequent merger, thereby making it more accurate and reliable due to the merging effect, i.e. united models set off mutual flaws [3].

Predictive and prescriptive analyses are implemented at the macro – and micro-levels. The assessment of anxiety index showcases the macroprediction analysis. Anxiety index is an algorithmic model to evaluate the public sentiment of millions of people [3]. It analyzes anxious notes in blogs determining the consumer behavior, behavior of investors, trends in stock indices, which is very important for justifying decisions at the macrolevel, since anxiety undermines economic growth. However, scarce information about macroevents makes it difficult to predict them because the less frequent such events, the more difficult the prediction [6].

In such cases, aspects of predictive and prescriptive analyses are treated at the macroeconomic and corporate level. Here we also consider points of business performance growth, which imply the use of digital analytics. As experts hold, such analytics is especially in demand in industries dealing with ultimate consumers, such as banking and financial services, insurance, public sector, pharmaceuticals, medicine, ITC, retailing [3]. Russia business digitization (coupled with digital analytics) began in telecommunications and banking. Its expansion continued in retailing and gradually permeated the industrial sector [6]. Currently, business in all sectors realize the need to collect, process and analyze data. However, this requires an understanding of analytics, strategy and action plan for data processing, including the online option [7]. Predictive and prescriptive analytics encompass a broad spectrum of aspects.

Customer Analytics. Customer analytics serves for attracting and retaining the clientele, increasing the market share of a company and its quality (profit margin). The clientele is segmented, with their behavior and respective impact being modeled and demand being

forecasted⁵. As part of customer analytics, analysts create customers' profiles, assigning multiple attributes to them, examining the description of certain types of customers which is based on their demographic and psychographic data and behavior on the Internet.

According to experts, nowadays it is inefficient to segment the clientele into conventional demographic categories. Psychographic factors, such as life style and mentality, should be taken into consideration⁶.

Psychographic factors, such as interests, opinions, values, activities, habits, life style, give an understanding of customers' behavior, making it predictable. Customers are analyzed through models which involve individual traits and provide for scoring. The higher the score, the more probable the behavior forecast. The last purchase date, shopping frequency and income are the most critical factors to consider in forecasting the demand.

Customer retention is an important mission of customer analytics, since it is much cheaper to retain customers, rather than attract new ones. Whether customers make account of certain product characteristics constitute a critical aspect of customer analytics [8], pertaining to product analytics.

Customer analytics helps improve the corporate reputation, improve the customers' loyalty, retain them and attract new ones, increase sales and make them less volatile, expand the market, leverage the ratio of profit margin and probability of sales (profitability and turnover).

Product Analytics. The practice pursues the product improvement and timely renewal of a product line. As part of product analytics, which directly relates to customer analytics, the product development trend is a cornerstone for the analysis⁷.

⁵ Skorik M.A. [Intellectual data analysis for predictive analysis]. *Statistika i vyzovy sovremennosti: materialy nauchnoi konferentsii* [Proc. Sci. Conf. Statistics and Challenges of the Contemporary Epoch]. Moscow, MESI Publ., 2015, 543 p.

⁶ Grigor'eva M. *Big, thick, wide: Zachem biznesu eti tri vida dannykh* [Big, thick, wide: Why does business need the three types of data?]. URL: <https://hbr-russia.ru/innovatsii/trendy/797004> (In Russ.)

Customer and product analytics serves for raising sales, reduction in customers' refusal, better compliance with the demand. Both types of analysis also produce savings, since they help optimize the distribution staff, accelerate the turnover of stocks, reduce logistic costs, eliminate unnecessary marketing efforts, raise the public awareness of the brand, stimulate sales, and pave the way to behavioral and customized marketing and tailor-made pricing. Relying on product analytics, companies can better satisfy customers' needs, timely adapt their product to changing demand, thereby securing higher sales.

Industrial Analytics (Business Process Analytics). It aims to make business processes more cost effective, shorter, more controllable, robust, safer and more environmentally friendly⁸. Industrial analytics handles data on the availability and movement of tangible and intangible items and business process data, including the information about fixed assets, acquisition of tangible and intangible assets, their flows, etc.⁹. Industrial analytics is based on the mathematical model of a technological process and a resource-based approach to analysis, which is common for economic analysis [9]. Evaluating business processes, analysts capture the information about the cost, pace, quality of business processes, technological state of equipment, out-of-service time, disrupted supplies. Industrial analytics focus on the interpretation and forecast of events in the real-time mode¹⁰.

Industrial analytics contribute to the quality of production planning, reduces the time and cost of business processes, concurrently increasing their quality through predictive actions intended to keep the enterprise's production systems operational. Industrial analytics helps enhance

⁷ *Kto takie produktovye analitiki i zachem oni nuzhny v komande?* [Who are product analysts and why should they join your team?]. URL: <https://habr.com/ru/company/wrike/blog/428125/> (In Russ.)

⁸ Mordashov A. *Kak Industriya 4.0 menyaet upravlenie* [How does Industry 4.0 realign the management?]. URL: <https://hbr-russia.ru/liderstvo/lidery/a24981>

⁹ Daugherty P.R., Wilson H.J. *Human + Machine: Reimagining Work in the Age of AI*. Harvard Business Press, 2018.

¹⁰ Milek T. *Potentsial tekhnologii BI v agrosektore: mashinnoe obuchenie na sluzhbe biznesa* [The potential of BI technologies in the agricultural sector: Machine learning for business purposes]. URL: http://www.tadviser.ru/images/c/c0/11._%D0%9C%D0%B8%D0%BB%D0%B5%D0%BA.pdf (In Russ.)

business performance, since it prevents the loss of resources, idle time and allows to use the resources more effectively, including the productivity of equipment, decrease the environmental footprint, better the quality of products and consequently increase sales [10].

Human Resources Analytics. People analytics is meant to attract and retain effective and creative talent, raise their motivation and loyalty, channel human resources to the firm. Talent is analyzed on the basis of demographic and psychographic characteristics, their productivity, interaction with customers. Similarly to customer analytics, HR analytics relies upon models inferring scores to forecast the employee's behavior.

Nowadays companies consider HR analytics as a priority practice, since human resources are the most valuable assets for many companies and undesired loss of talent may cause considerable damage¹¹. Experts found out that aspects below are key factors, predictors of the employee's dismissal: remuneration – the lower, the remuneration, the less frequent the pay rise. As for the employee's performance, the worse the performance, the more probable the dismissal. As for the frequency of the employee's relocation within the company, the less frequent he/she is relocated, the more probable the dismissal. The promotion without a proper pay rise often ends up in dismissals.

HR analytics allows to influence the staff productivity, undertake staff retention measures and prepare the company for an unavoidable quit of some of them. HR analytics spurs the productivity and creative performance of people, channels the talent into the company, make the pool of human resources stable, reduces the turnover rate and relative HR expenditures.

Fraud Analytics. It prevents fraudulent actions of insiders and outsiders. To detect fraud, analysts handle a substantial body of data, including fraudulent and legitimate operations, and trace some anomalies, that is, signs of fraud which are further taken into consideration to locate fraudulent transactions and *mala fide*

counterparts. Fraud analytics refers to the classification agents, determining whether the fraud case is concerned, factors that are typical of a certain group.

Fraud analytics helps improve the corporate image, reputation, and decrease losses from fraud, making its operations more transparent and effective, lowering the credit risk as part of relationships with counterparts.

Business Environment Analytics. The practice optimizes the cooperation with stakeholders and streams intellectual resources to the company from a broad array of stakeholders. Analysts collect and process information about would-be and real counterparts of the company, i.e. suppliers, marketing intermediaries, competitors, other counterparts, and stakeholders, thus opening vast business development capabilities – crowd sourcing, collective mind [3]. This practice is very significant for business analysis, since companies gain a broader access to capabilities of many stakeholders. Similarly to the way business continuously grows, raises resources in open financial markets, it can do so with respect to other resources, such as tangible, human, intellectual resources from a broad array of stakeholders. According to Jeff How, given certain favorable conditions, a crowd will definitely outperform any number of employees [3].

Analyzing its business environment and ecosystem, companies strive to evolve and improve its business by involving as many external resources as possible, accelerating innovation, enhancing its R&D, spurring business growth, business value for stakeholders.

Corporate Analytics. The practice integrates all blocks of analysis into the corporate mechanism for decision-making, evaluates whether such decisions are effective, and appraises business value for stakeholders [11].

Table 1 enlists points for raising the corporate performance, which are identified through the analysis.

There should be three components to implement algorithms of digital analysis, i.e. structured and non-structured data, processing tools and

¹¹ Kholkin S. *K uvol'neniyu gotovy* [Awaiting to be fired]. URL: <https://hbr-russia.ru/management/upravlenie-personalom/776920> (In Russ.)

hypotheses. Virtually extracting knowledge from the data [3], analysis helps optimize the decision-making process substantially, since the data serve as early warning signals, thereby modeling the behavior of economic agents and substantiating the business development trajectory and make its more valuable for stakeholders.

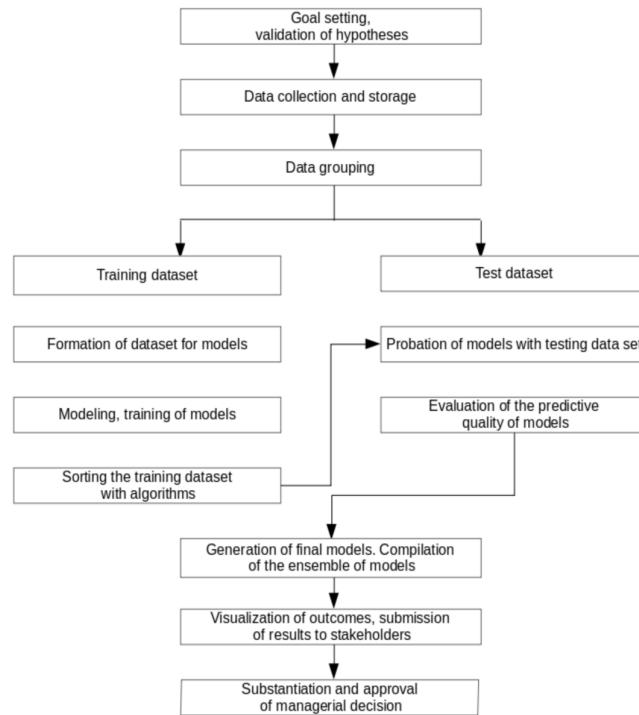
Table 1
Description of aspects studied as part digital analytics

Block of analysis	Key algorithm building value	Managerial decisions
Customer Analytics	<p>Market segmentation: the classification and clusterization of markets.</p> <p>Customer scoring: assessment of their characteristics, life cycle.</p> <p>Study into behavioral models of consumers, identification of demographic and psychographic characteristics that influence consumers' behavior.</p> <p>Modeling of consumer behavior, trend setting, modeling.</p> <p>Forecast of the demand with regression factor models.</p> <p>Sales trend monitoring by market segments and identification of trends.</p> <p>Identification of factors of customer loyalty and satisfaction.</p> <p>Customization ensuring the transition to targeted behavioral marketing.</p> <p>Association analysis of customer characteristics.</p> <p>Identification of risk groups, i.e. customers who may refuse to buy the company's products</p>	<p>The development of recommendation engines, i.e. recommendation for customers in line with their choices, views, demographic and psychographic characteristics.</p> <p>Customer retention and loyalty measures.</p> <p>Customization of offering, adaptation of products and marketing to customers' needs, substantiation of changes in products and marketing, i.e. pricing policy, distribution mechanism, sales promotion, marketing optimization.</p> <p>Improvement of products and product portfolio by considering tastes, customer preferences, development of new products, new product mix, optimization of corporate business portfolio.</p> <p>Optimization of promotion campaigns, direct marketing: the selection of a target segment and content of advertisement (target marketing).</p> <p>Pricing optimization: the assessment of demand elasticity, substantiation of rebates for certain customers, diversified pricing strategy</p>
Product Analytics	<p>Product demand monitoring, identification of weaknesses and preferable qualities, functional requirements, trends setting.</p> <p>Product classification and clusterization.</p> <p>Identification of factors and respective effect of product qualities and marketing aspects on the demand, setting of regression models of the demand for products.</p> <p>Association analysis of the demand for various types of products, identification of complement products.</p> <p>Finding target consumers of new products (product targeting).</p> <p>Detection of unsatisfied demand.</p> <p>Monitoring of marketing efficiency</p>	
Industrial Analytics	<p>Monitoring of the state and movement of tangible and intangible items, examination of various infrastructure systems, technological processes.</p> <p>Technical control and forecast of tangible items, including equipment break-downs.</p> <p>Monitoring of purchased tangible assets, analysis of prices and quality, reliability and performance of suppliers.</p> <p>Record of refusal statistics and operating time of tangible assets.</p> <p>Monitoring of investment processes.</p>	<p>Optimization of business processes, technological processes.</p> <p>Optimization of technological maintenance frequency, relevant technological measures to maintain production capacities, transition from regulatory maintenance to condition-based maintenance.</p> <p>Adjustment of production volumes to sales trends.</p> <p>Supply chain management, substantiation of procurement needs, optimization of stocks, logistics.</p>

	<p>Analysis of IoT data, their mutual and external interaction.</p> <p>Monitoring of supplies, materials, manpower and other resources used.</p> <p>Monitoring of product quality, deficiency prevention.</p> <p>Monitoring of reserves of natural resource</p>	<p>Cost optimization, loss reduction, enhancement of resource use</p>
HR Analytics	<p>Monitoring of demographic and psychographic characteristics, raising the understanding of staff motivation.</p> <p>Monitoring of relationship, interaction of personnel, service quality.</p> <p>Evaluation of involvement, health, well-being, productivity of employees.</p> <p>People scoring; development of scoring models to appraise personnel; staff behavior modeling.</p> <p>Determination of the effective employee's qualities; identification of leaders and innovators.</p> <p>Study into methods for influencing the creativity and productivity of personnel.</p> <p>Monitoring of staff relocation, employee attrition probability assessment, prediction of talent movements</p>	<p>Articulation of the effective HR policy, setting up new talent requirements.</p> <p>Improvement of the talent motivation mechanism, actions to tap employees' potential, increase their productivity and creativity.</p> <p>Employee turnover management, talent retention actions.</p> <p>Activities for recruitment of specific talent</p>
Fraud Analytics	<p>Classification and clusterization of transactions, identification of legitimate and illegitimate transactions.</p> <p>Analysis of anomalies, identification of unusual transactions.</p> <p>Detection of reporting manipulations.</p> <p>Financial monitoring of counterparts, identification of <i>mala fide</i> counterparts.</p> <p>Monitoring of large and unusual transactions, i.e. those ones where prices substantially differ from market ones, transactions with unreliable counterparts, parties affiliated with talent, etc.</p> <p>Compliance checks of business processes, including procurement</p>	<p>Making preventive decisions on suspicious transactions.</p> <p>Timely identification of <i>mala fide</i> counterparts.</p> <p>Timely identification of <i>mala fide</i> employees.</p> <p>Improvement of internal controls and internal auditing.</p> <p>Prevention of unauthorized access to information</p>
Business Environment Analytics, Ecosystem Analytics	<p>Classification and clusterization of stakeholders.</p> <p>Monitoring of a broad and narrow group of stakeholders, i.e. resource markets, including intellectual ones.</p> <p>Evaluation of real and potential counterparts, capabilities for outsourcing, crowdsourcing, crowdfunding, crowdlending, etc.</p> <p>Competition monitoring: evaluation of cooperation opportunities, benchmarking of products, innovation, business models.</p> <p>Identification of ideas and innovation outside, evaluation of innovation proceeding from customers, partners, competitors, a broad group of stakeholders (crowdsourcing)</p>	<p>Contracting with the most effective suppliers of tangible, financial, intellectual, other resources.</p> <p>Optimization of business model, business structure.</p> <p>Revitalization of innovative activities.</p> <p>Acceleration of business growth, increased performance through investment.</p> <p>Optimization of competitor cooperation algorithms</p>

Source: Authoring

Figure 1
A modeling algorithm



Source: Authoring

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Conflict-of-interest notification

I, the author of this article, bindingly and explicitly declare of the partial and total lack of actual or potential conflict of interest with any other third party whatsoever, which may arise as a result of the publication of this article. This statement relates to the study, data collection and interpretation, writing and preparation of the article, and the decision to submit the manuscript for publication.